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MARKOV PROCESSES APPLIED TO CONTROL REPLACEMENT AND  
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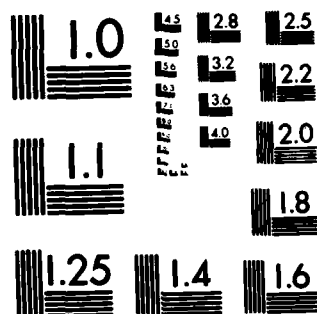
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19. ABSTRACT (Continue on reverse if necessary and identify by block number) Research efforts during this period concentrated on the following topics: A. <u>Deformation of Solids</u> - work on the topic has progressed to the point where the physical mechanisms of creep can be brought in. B. <u>Excursions of Markov Processes</u> - Two papers by Salminen are completed in this area. C. <u>Stochastic Differential Geometry</u> - Starting with a Brownian motion on a Riemannian manifold, the exit time from a ball is considered. The distribution of the exit time is used to investigate the geometric structure of the manifold. This report summarizes the progress made and lists completed publications resulting from the research.					
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MARKOV PROCESSES  
APPLIED TO CONTROL, REPLACEMENT, AND SIGNAL ANALYSIS

for the period  
1 June 1982 - 31 December 1982

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## A. Deformations of solids

Our work on the topic has progressed to the point where the physical mechanism of creep can be brought in.

Consider a unit length of wire subjected to a unit stress at a high enough temperature to cause creep. Let  $X(p,t)$  be the position at time  $t$  of the point that was at  $p$  originally. An independence argument shows that, for fixed  $t$ ,  $p \mapsto X(p,t)$  has stationary and independent increments. On the other hand, writing  $X_t$  for the function  $p \mapsto X(p,t)$ , it is reasonable to assume that  $(X_t)$  is a Markov process. General results on stationary and independent increments yield that,

$$X(p,t) = (1 + \frac{1}{E}) p + \sum_1 Z(t - T_1) I_{\{T_1 \leq t, Y_1 \leq p\}}$$

where  $(T_1, Y_1)_{1 \in \mathbb{N}}$  is an enumeration of the times and positions at which defects occur and  $Z_1(t)$  is the size of the "crack" at position  $Y_1$  at time  $T_1 + t$ . With  $Z_1$  considered as a member of a space of increasing functions, the triplets  $(T_1, Y_1, Z_1)$  form the points of a Poisson random measure. Further, the Markov property of the process  $(X_t)$  coupled with some physical reasoning yields the hypothesis that each  $Z_1$  is an increasing Markov process. The general form of such Markov processes as  $Z_1$  is known from our earlier work with J. JACOD. What remains is to figure out the exact shape of  $Z_1$  by physical considerations.

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MATTHEW J. KERPNER  
Chief, Technical Information Division

## B. Excursions of Markov processes

This is joint work with P. SALMINEN, who is working as a post-doctoral fellow supported by this grant.

Two papers by SALMINEN (Brownian excursions revisited, and Mixing Markovian laws, with an application to path decompositions) are completed and their copies are enclosed.

We have also made some progress on the following problem. Suppose that a particle moves in a space  $E$ , its motion is known to be a Markov process  $X$ , and the law of  $X$  is known. Suppose also that we have detectors placed at every point of a subset  $D$  of  $E$ , so that we have a record of the times  $t$  and positions  $X_t$  whenever  $X_t \in D$ . Otherwise, we do not know where the particle is (or was). We call the information  $\{(t, X_t): X_t \in D\}$  the trace of  $X$  on  $D$ . The problem is to find the conditional law of  $X$  given this trace on  $D$ .

In the case where  $X$  is a Brownian motion on  $(-\infty, \infty)$  and the detectors are placed at the points of  $D = \{\dots, -1, 0, 1, 2, \dots\}$ , we are able to describe the conditional law of  $X$  given the trace by using the results of ITO and WILLIAMS on the Brownian excursions. Currently we are working on generalizations to more general motions on more general sets.

## C. Stochastic differential geometry

Work on this area is due to M. PINSKY. Starting with a Brownian motion on a Riemannian manifold, the exit time from a

ball is considered. The distribution of the exit time is used to investigate the geometric structure of the manifold. For this purpose, asymptotic expansions are obtained for the expected value and the variance of the exit time  $T_\epsilon$  from the ball  $\{x: d(x,m) \leq \epsilon\}$ ,  $m$  being the initial position and  $d$  the Riemannian distance. The asymptotic expansion for  $E[T_\epsilon]$  can be used to tell if the metric (of the manifold) is flat, for instance. Further, the asymptotic expansion for  $\text{Var}(T_\epsilon)$  allows one to give a characterization of flat metrics independent of the dimension: if  $\text{Var}_m(T_\epsilon) = \text{constant} \times \epsilon^4$  for all points  $m$  in the manifold, then the metric is flat. The methods used are a combination of stochastic analysis and Riemannian geometry: Dynkin's formula, its extension to a stochastic Taylor's formula, then a perturbation theory for the Laplacian etc.

#### D. A variation from the proposal

The proposed book project on stochastic integrals was to be joint work with M. HARRISON. This joint project is being dropped. HARRISON is writing on applications to "buffered production systems with Brownian flows." We are planning to write on stochastic integrals, separately, with emphasis on applications to Markov processes.